REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
03-04-2015	Final Report	1-Aug-2013 - 31-Jan-2015

4. TITLE AND SUBTITLE

Final Report: Photoelectron Spectroscopy of Energetic Materials and Catalytic Clusters with a 26.5 eV Tabletop Laser

5a. CONTRACT NUMBER
W911NF-13-1-0343

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
611103

6. AUTHORS

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES

Colorado State University - Ft. Collins
Sponsored Programs
2002 Campus Delivery
Fort Collins, CO 80523 -2002

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES)

U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSOR/MONITOR'S ACRONYM(S)
ARO

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
63320-CH-RIP.1

12. DISTRIBUTION AVAILIBILITY STATEMENT

Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

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14. ABSTRACT

This DURIP grant was for the design and construction of a photoelectron spectrometer (PES) to study the electronic energy levels and structures of mass selected energetic materials and neutral catalytic clusters. The apparatus is now finished and presently acquiring data on representative sample in both areas.We present data for FeO2 as an initial first experiment for mass spectra and PES of a known sample. The clusters are generated by laser ablation and the electrons are collected through a magnetic bottle time of flight analyzer following the mass selection of FeO2-.

15. SUBJECT TERMS

photoelectron spectroscopy, ion states, energetic materials, neutral clusters, catalysis, heterogeneous catalysis, model energetic materials

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Elliot Bernstein
UU	UU	UU	UU		19b. TELEPHONE NUMBER: 970-491-6347

Report Title

Final Report: Photoelectron Spectroscopy of Energetic Materials and Catalytic Clusters with a 26.5 eV Tabletop Laser

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This DURIP grant was for the design and construction of a photoelectron spectrometer (PES) to study the electronic energy levels and structures of mass selected energetic materials and neutral catalytic clusters. The apparatus is now finished and presently acquiring data on representative sample in both areas.We present data for FeO2 as an initial first experiment for mass spectra and PES of a known sample. The clusters are generated by laser ablation and the electrons are collected through a magnetic bottle time of flight analyzer following the mass selection of FeO2-.

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Number of Presentations: 0.00

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Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

see attachment

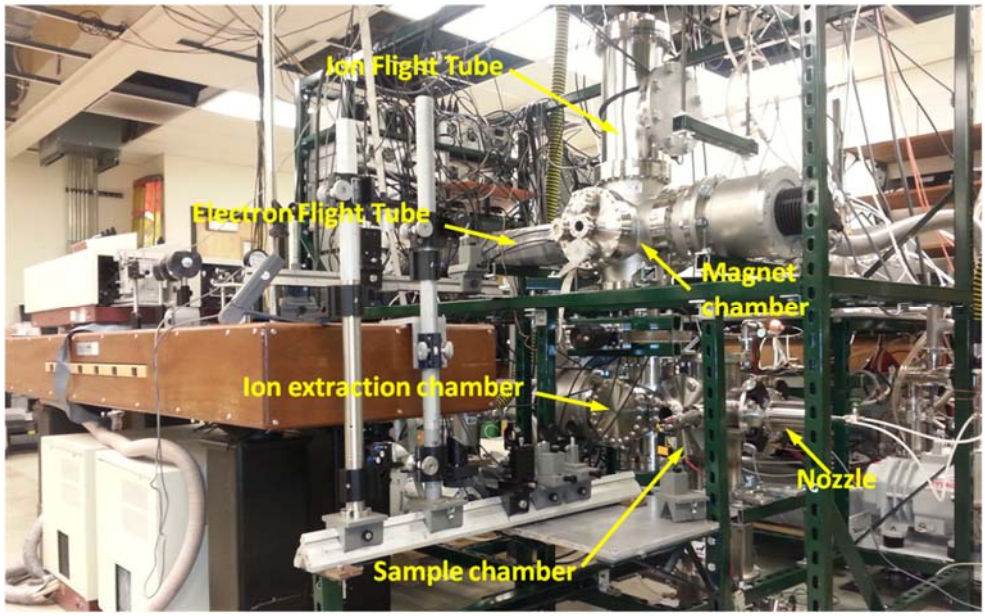
Technology Transfer

not yet

DURIP FINAL TECHNICAL REPORT

[W911NF-13-1-0343]

A magnetic-bottle time-of-flight (MTOF) photoelectron spectroscopy (PES) apparatus is constructed in our lab. Figure 1 shows a photo and a schematic view of our magnetic bottle time of flight photoelectron spectroscopy (MBTOF-PES) apparatus. It consists of a laser vaporization cluster/molecular source, an orthogonal acceleration/extraction reflectron time of flight (oaRETOF) mass spectrometer, a mass gate, a momentum decelerator, and a MBTOF electron analyzer.



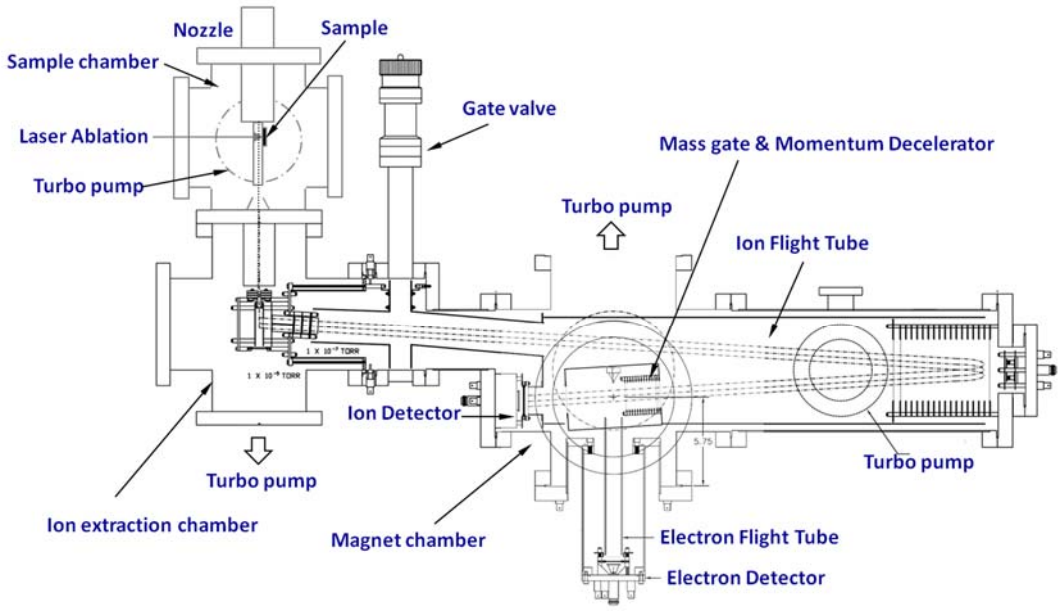


Figure 1. Photo and schematic view of the laser-vaporization/magnetic-bottle photoelectron spectroscopy apparatus.

Negative ions are generated in a laser ablation source, and carried by helium expansion gas, which is pulsed into the vacuum by a supersonic nozzle (R. M. Jordan, Co.) with a backing pressure of typically 75 psi. The negative ions are extracted perpendicularly from the beam by a -250 V high voltage pulse and are subjected to an oaRETOF mass analysis with +750 V on the liner. A three-grid mass gate is used for mass selection as shown in Figure 2. The first and third grids are at the liner voltage (+750 V), and the middle grid is at negative high voltage -250 V, so that no ions are able to pass. Once the desired ion arrives at the first grid, the high voltage on the middle grid is pulsed to the liner voltage (+750 V) for a short period allowing the ion to pass unaffected. Following the mass gate, the selected ion beam enters a momentum decelerator. Once the ion packet passes the third grid of the mass gate, a positive square high voltage pulse (+1750 V) is applied to this grid for the momentum deceleration. The high voltage is pulsed back to the liner voltage before the ion packet leaves the deceleration stack.

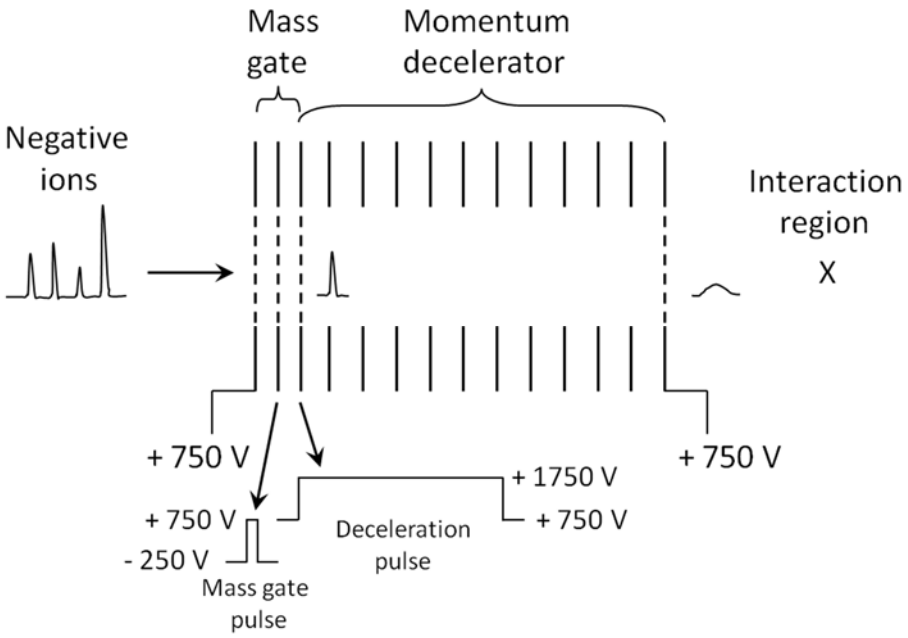


Figure 2. The mass gate and the momentum decelerator.

Figure 3 illustrates the working of the mass gate. Figure 4(a) shows the mass spectrum of $Fe_mO_n^-$ from laser vaporization of a Fe target reacting with oxygen seeded in helium (1% O_2/He) expansion gas. Figure 4(b) shows the mass selected FeO_2^- ion peak. We have obtained a mass resolution ($M/\Delta M$) of more than 1000 at this mass region. The mass gate is able to select the desired ion peak unaffected. The FeO_2^- ion is used to test our photoelectron spectroscopy apparatus. The FeO_2^- ion is mass selected by the mass gate and subsequently decelerated by a momentum decelerator before interacting with the detachment laser. A third harmonic output (355 nm) of *Q*-switched Nd:YAG laser is used for the photo detachment. The photoelectrons are collected by the magnetic bottle and parallelized down to a ~1 m long TOF tube for electron kinetic energy analysis. The obtained photoelectron spectrometry of FeO_2^- is shown in Figure 4. We are still trying to optimize the conditions of our apparatus to get better resolution of the photoelectron spectrometry. Next step, our home-made tabletop extreme ultraviolet (soft x-ray) EUV laser (26.5 eV/photon) shown in Figure 5 will be connected to the apparatus for high photodetachment energy PES experiment.

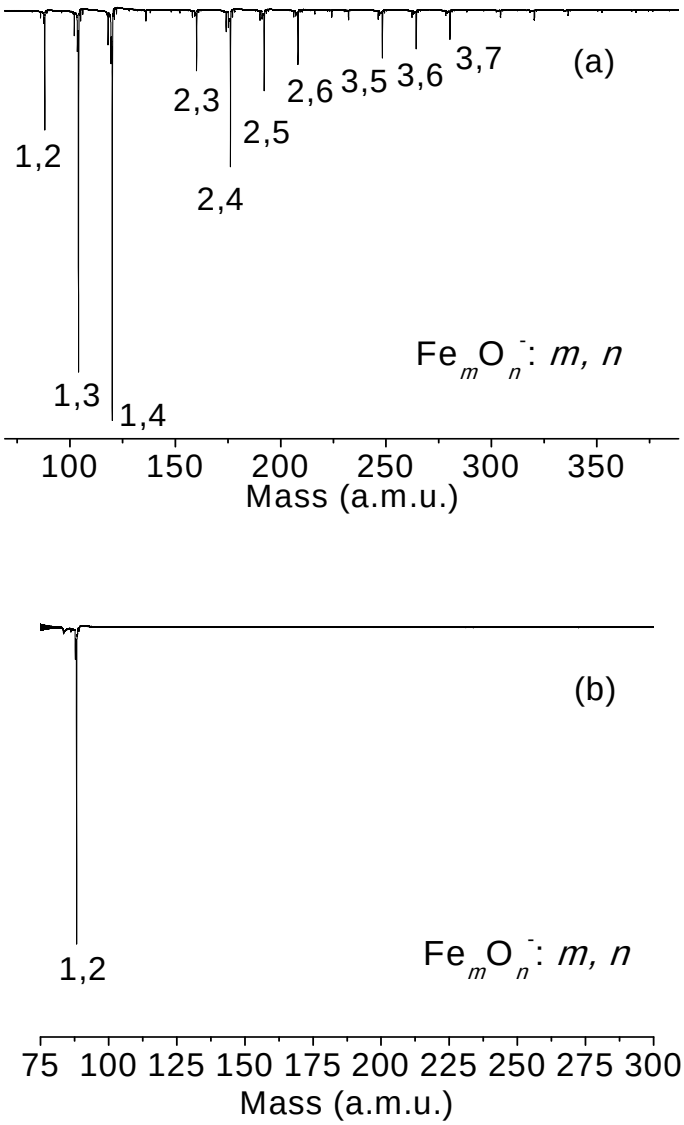


Figure 3. (a) Mass spectrum of $Fe_mO_n^-$ from laser vaporization of a Fe disk; (b) Mass-selected FeO_2^- ion peak.

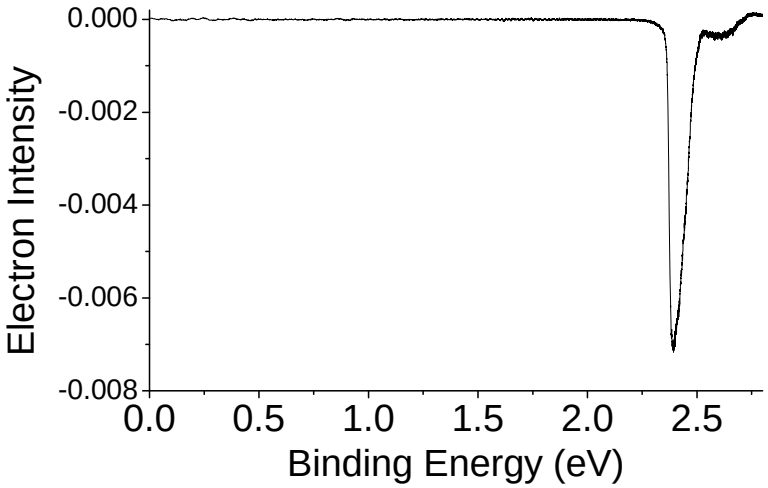


Figure 4. The photoelectron spectrometry of FeO_2^- at 355nm (3.49 eV photon energy).

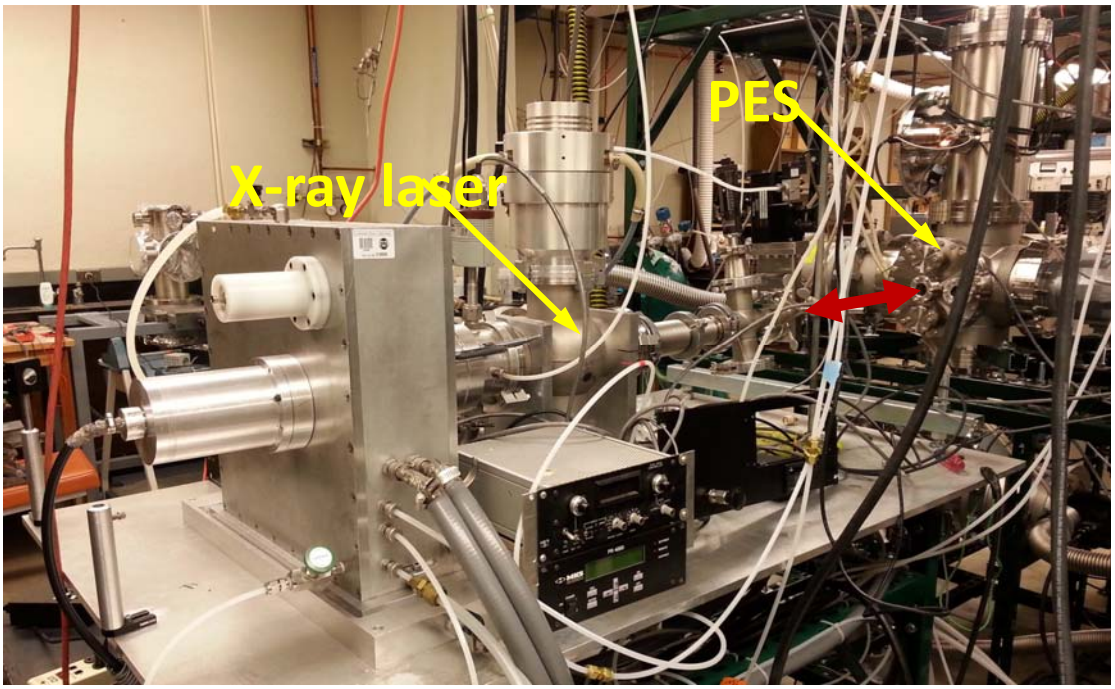


Figure 5. Photo view of the X-ray laser apparatus.